Volume 9 JUNE 12, 1934 Number 4

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM OF THE

ANN ARBOR MEETING

AT

THE UNIVERSITY OF MICHIGAN

JUNE 28, 29 and 30, 1934

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary W. L. Severinghaus, Columbia University, New York, N. Y.

Entered at the post office at Lancaster, Pa., as second class matter.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

ANN ARBOR MEETING, JUNE 28–30, 1934

THE 193rd meeting of the American Physical Society will be held in Ann Arbor, Michigan, at the University of Michigan, on Thursday, Friday, and Saturday, June 28, 29, and 30, 1934. The first day of the meeting consists of visits to the Ford Plant and Greenfield Village Museums at Dearborn, Michigan. The scientific sessions in Ann Arbor include an address on "The General Nuclear Problem" by Professor George Gamow of the Polytechnical Institute, Leningrad, and on Saturday morning a symposium on "Nuclear Moment."

CALENDAR

Eastern Standard Time

Thursday, June 28	
9:00 A.M. to 5 P.M.	Registration. Michigan Union, Ann Arbor or Dearborn Inn, Dearborn, Michigan
10:00 A.M. to 3:00 P.M.	Trips through the Ford Plant at River Rouge and through the Greenfield Village, Dearborn
12:30 P.M.	Luncheon. Dearborn Inn—Dining Room and Coffee Room Service
5:00 P.M.	Leave Dearborn for Ann Arbor
7:00 P.M.	Dinner in Ann Arbor. Michigan League Dining Room or Cafeteria
Friday, June 29	
9:00 A.M. to 12:00 M.	Registration at Mosher-Jordan Hall or Hutchins Hall
9:30 A.M.	Hutchins Hall Contributed papers. Room 100, Numbers 1–12 Contributed papers. Room 150, Numbers 13–23 Contributed papers. Room 250, Numbers 24–35
12:30 P.M.	Luncheon, Michigan Union—dining room and cafeteria service, or Michigan League—dining room and cafeteria service
1:00 P.M.	Ladies luncheon at Barton Hills Country Club
2:00 P.M.	Lecture by Professor George Gamow. Hutchins Hall, Room 100—Number 36
3:15 P.M.	Meeting of the Council. Hutchins Hall, Room 100
3:30 P.M.	Sports
6:00 P.M. to 11:00 P.M.	Dinner and theater party. Michigan League
Saturday, June 30	
10:00 A.M.	Hutchins Hall, Room 100, Symposium on Nuclear Moment. Numbers 37–41
12:30 P.M.	Luncheon
3:00 P.M.	Scenic drive and afternoon tea in the garden of the Michigan League or a swimming party and picnic supper at Portage Lake.

RAILROADS

Ann Arbor is on the main line of the Michigan Central between Detroit and Chicago and on the Ann Arbor Railroad which runs north from Toledo. Dearborn (9 miles out of Detroit) is also on the Michigan Central Railroad.

Should railroad connections result in lengthy delays at junctions or terminals near Ann Arbor

or Dearborn, both places are readily reached in a comparatively short time by bus.

Railroad Rates

No application for special rates to Ann Arbor has been made. Each one should consult his local ticket agent for the best possible railroad rates at the time of the meeting keeping in mind the possibility of taking advantage of the special rates to the Chicago Fair.

Registration

Members are requested to register as soon as possible either on Thursday at the Dearborn Inn, Dearborn, or on Friday at the Michigan Union, Ann Arbor.

As authorized by the Council of the Society a **registration fee of one dollar ($1.00)** will be collected from each adult in attendance.

Automobiles

Ann Arbor can be reached from any direction over fine public highways. Persons on vacation should consider that after the meeting a short day's journey brings them into the north Michigan resort region of inland lakes and Great Lakes beaches. A little farther north lie the Straits of Mackinac. The ter-centennial celebration of the landing of the first white man at Mackinac Island starts Sunday, July 1 at Mackinac Island and extends to all of the northern resort towns during the following week. From here one could proceed north to Sault Ste Marie. Turning west from Sault Ste Marie one goes first through the upper peninsula of Michigan into the lake regions of Wisconsin, and south to the World's Fair at Chicago or farther west through the lake region of Minnesota to the great national parks. Turning east from the Soo and travelling along the North Channel with its easy access to the many beautiful bays for which this channel region is celebrated, one comes by turning south at North Bay to the wonderfully scenic region of Muskoka lakes, thence south to Toronto or east to Montreal. Throughout the roads are excellent and good accommodations are very reasonable. Those expecting to attend the fair in Chicago will find Ann Arbor on the direct route from all points in the east.

Automobile parking. Adequate and convenient parking places will be provided for automobiles.

Accommodations

Headquarters. The headquarters for this meeting are in the Mosher-Jordan Dormitory where both men and women may be accommodated. Lodgings for from two to four hundred persons may be had here. This is the largest and most recently built dormitory for university women. Each room contains two single beds. The fee will be $1.00 per night for each person. There is a very limited number of rooms furnished with a single bed at the same rate. If the weather should be inclement, breakfast for the ladies can be served in the Mosher-Jordan dormitory. It is desirable that reservations be made early and for this purpose address either the secretary of the Physics Department or Miss Ellen B. Stevenson, Business Manager of the Dormitories, University of Michigan, Ann Arbor, Michigan.

Hotels. Those preferring hotel service may obtain rooms at the Michigan Union or the Michigan League of which however there is but a limited number available. Their rates, including those of the Ann Arbor hotels, are as follows:

Michigan Union	$1.50 to $3.00
Michigan League	$2.50 to $3.00
Allenel Hotel	$1.50 to $3.00
Milner Hotel	$1.00 to $1.50

Meals. Meals may be had at either the Michigan League or the Michigan Union cafeterias or dining rooms.

Entertainment

In response to many requests for an opportunity to visit Greenfield Village and the Ford Motor Company, arrangements have been made to spend Thursday at Dearborn, Michigan. This small village on the Michigan Central is 9 miles west of Detroit and 27 miles east of Ann Arbor. The one daily train from the east which stops there arrives at 8:50 A.M. Eastern Standard Time, leaving Detroit at 8:30, and the one train from the west arrives at Dearborn at 9:30 A.M.

Eastern Standard Time. Passengers not able to make these particular trains should complete their journey from Detroit or Ann Arbor by motor bus.

To see the various exhibits at Greenfield Village which include among other things the original Edison Laboratory, or to go through the Ford plant requires between two and three hours each, so that persons desiring to see both should plan to be in Dearborn by 10 o'clock Thursday morning and complete one trip before lunch. Upon arrival in Dearborn proceed at once to the Dearborn Inn which is across the road from Greenfield Village for registration and formation of parties for each of which a guide will be furnished. The Ford plant is about a ten-minute ride from the Inn. A special tour which will show the points of scientific interest will be arranged in addition to the regular tour which shows mainly the methods of assemblage.

The University of Michigan Athletic Association extends an invitation to the Society to use its golf course, swimming pool, and tennis courts. A special greens fee reduced to 40¢ will be made for those playing golf. The tennis courts of Mosher-Jordan dormitory, immediately adjacent to the dormitory, will be at the disposal of Society members at any time upon the presentation of cards which may be obtained at the Registration Desk. There are other interesting golf courses near the city which may be played, upon the payment of the usual greens fee. Small swimming parties at nearby lakes will be arranged if desired.

The Clements Memorial Library, containing an unrivalled collection of books, manuscripts, and maps of early American history, will be open to inspection at a time to be announced later. Also the University Library will place on exhibit its collection of early scientific books.

Friday evening there will be the usual Physical Society dinner followed by a theater party in the Lydia Mendelssohn Theater which is in the Michigan League building. Tickets for the dinner and play combined will be $1.50. The play will be one presented by the Michigan Repertory Players.

There will be a luncheon for the ladies at one o'clock Friday at Barton Hills Country Club (75¢). Tickets should be purchased Thursday or early Friday morning. On Saturday afternoon there will be a scenic drive followed by tea in the garden of the Michigan League, or for those who prefer it, a swimming party and a picnic supper at Portage Lake. Announcement of other entertainment will appear upon the Bulletin Board of Mosher-Jordan dormitory.

Information

Mail, telephone, telegraph. Up until Thursday noon telephone and telegraph messages should be directed to the Dearborn Inn. Beginning

with Thursday night all mail, telephone and telegraph messages should be addressed to the East Physics Building of the University. Outgoing telegrams and telephone messages can be sent from the University. A map of the campus and the city will be furnished those attending at the time of registration.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.) Papers received after the program has been printed will be placed in the supplementary program.

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Editorial Secretary, The American Institute of Physics Incorporated, 11 East 38th Street, New York, N. Y.

Other meetings for the current season are as follows:

192. June 18–23, 1934. Berkeley, California. Joint meeting with A.A.A.S.

194. November 30–December 1, 1934. St. Louis, Missouri.

195. December, 1934. Pacific Coast. Time and place to be announced later.

196. Annual Meeting. December 27–29, 1934. Pittsburgh, Pennsylvania.

W. L. Severinghaus, *Secretary*,
Columbia University, New York, N. Y.

June 12, 1934.

Advance Registration Card

Ann Arbor Meeting, June 28–30, 1934

Please return this card as soon as possible to Professor H. M. Randall if you expect to attend the meeting.

Name.....
Last name First name Other initials

Others in party:.....men.....women.....children (give ages)

Will arrive about.....A.M. / P.M. June.....by Train.....Bus.....Automobile.....

Will remain until about.....A.M. / P.M. June.....

If house guest give name of host.....

If University rooms are desired how many.....

Hotel rooms have been obtained / requested at.....

Do you plan to see Greenfield Village, Dearborn?.....

Do you plan to visit the Ford Plant, Dearborn?.....

Arrange scientific conferences, if possible on.....

Friday Morning at 9:30 O'clock

Hutchins Hall, Room 100

1. A Coincidence Test of the Corpuscular Hypothesis of Cosmic Rays. D. S. Hsiung, *University of Chicago. (Introduced by A. H. Compton.)*—Three Geiger-Müller counters were arranged vertically so that double coincidences were recorded by counters 1 and 2 and triple coincidences by counters 1, 2 and 3 simultaneously. The third counter was permanently shielded by a lead cylinder of 2.5 cm thickness, which is sufficient to absorb the secondaries produced in the absorber. Counts were made under three conditions:

	Double(hr^{-1})	Triple(hr^{-1})
(*A*) Without lead	202.44±1.84	42.43±0.83
(*B*) With 20 cm of lead between counters 1 and 2	124.48±1.43	30.50±0.50
(*C*) With 20 cm of lead above counter 1	142.17±1.08	32.55±0.52

The data can be interpreted by assuming that the coincidences are due chiefly to penetrating ionizing particles, some of which are stopped by the lead (for which *B* should equal *C*), with the addition of a few coincidences in case *C* due to secondaries. It does not appear possible to account for these coincidences in terms of corpuscles excited by photons unless the photons either are completely absorbed by the atmosphere before reaching the apparatus, or are accompanied throughout their path by ionizing particles, which would practically mean treating the photons as ionizing particles.

2. Is the Neutron an Elementary Particle? Alfred Landé, *Ohio State University.*—The sum of the masses proton+electron = 1.0072+0.00055 = 1.00778 is larger than the neutron mass 1.0068 of Chadwick and Ladenburg, but smaller than the neutron mass 1.010 of Curie-Joliot. If the latter value is correct, it would be difficult to think of a neutron as a stable compound of a proton and an electron. However the interpretation of magnetic moments of higher nuclei containing an odd number of neutrons shows that the neutron has a magnetic moment of at least −0.6 nuclear magnetons. The existence of a magnetic moment without a resultant charge seems to indicate that this charge zero is composed of a negative and a positive part. The negative sign of the magnetic moment means then, that the negative charge is bound to a lighter share and the positive charge to a heavier share of the mass of the neutron.

3. Magnetic Dipole Radiation and the Atmospheric Absorption Bands of Oxygen. J. H. Van Vleck, *University of Wisconsin.*—On the basis of configuration theory, it is much more reasonable that the upper state of the ${}^3\Sigma_g^- - {}^1\Sigma$ atmospheric absorption bands be ${}^1\Sigma_g^+$ than ${}^1\Sigma_u^-$. With such an assignment, these bands are usually ascribed to quadrupole radiation, as $g-g$ transitions are forbidden in ordinary electric dipole radiation. The quadrupole formulas of Rubinowitz, however, yield an incorrect rotational intensity structure, as they predict transitions by two units in J, etc. On the other hand, Schlapp's intensity calculations (Phys. Rev. **39**, 806 (1932)) agreed with experiment, but assumed dipole transitions, and so apparently presupposed a ${}^1\Sigma_u^-$ upper state. A solution of this dilemma is obtained by interpreting the atmospheric bands as magnetic dipole radiation, of the general type treated by Brinkmann, Stevenson, and Condon. The upper state is then ${}^1\Sigma_g^+$, and still the relative intensities are those calculated by Schlapp. The Rubinowitz quadrupole radiation would also be present, but its comparative faintness explains why double transitions in J have escaped observation. The observed absolute intensities are much greater than to be expected for Rubinowitz quadrupoles, much less than for ordinary dipoles, but of about the right order for magnetic dipoles. Details will be given in a paper to be submitted to the *Astrophysical Journal.*

4. The Four Vector Problem and Intensities in Platinum-Like Spectra. A. T. Goble, *University of Wisconsin.*—In a previous paper (Phys. Rev. **42**, 909 (Abstract 33) (1932)) the theories of Johnson and of Shortley (ibid. **38**, 1628 (1931); **40**, 185 (1932)) were applied to the $5d^96_p$ configuration of Pb V and Bi VI. The calculations are inclusive of spin-orbit interaction, which is not small compared to the electrostatic. With a few modifications in the method of computation, the same work has been applied to the classification of all the isoelectronic sequence Pt I, Au II, Hg III, Tl IV, Pb V, and Bi VI. The agreement between theory and experiment is satisfactory in all cases except Pt I where the $5d^86s6p$ configuration perturbs the one studied. The Houston problem was also solved for the $5d^96s$ configuration for each of the elements. These results make it possible to compute the transformation matrices to go from the $j-j$ system of representation to the actual one. Thus one can compute the transition probabilities for $5d^96s-5d^96p$ in intermediate coupling. From these one can predict the relative intensities of the spectral lines. The results are in as good agreement with experiment as one can expect considering the method of excitation used and the method of estimating the observed intensities.

5. Spectral Multiplets Arising from Configurations of the Type d^kmsns and d^kms. ($k=1\cdots9$.) Robert A. Merrill, *University of Wisconsin.*—The application of Dirac's vector model to complex spectra has been considered by J. H. Van Vleck (Phys. Rev. **45**, 405 (1934)). By means of this model and Johnson's formulae for the four vector problem (Phys. Rev. **38**, 1628 (1931)) the energy values of configurations of the type d^kmsns may be calculated if the d^k multiplets conform to Russell-Saunders coupling. The spin-orbit energy is *not* assumed small compared to the electrostatic energy coupling d^k to ms and ns. The following multiplets have been considered: Cu I, $3d^9(^2D)4s5s$; Yt I, $4d(^2D)5s6s$; Ni I, $3d^8(^3F)4s5s$; Zr I, $4d^2(^3F)5s6s$; Co I, $3d^7(^4F)4s5s$; Fe I, $3d^6(^5D)4s5s$; Ti I, $3d^2(^3F)4s6s$. The agreement with experiment is better with the four vector problem (L_d, S_d, s_m, s_n) than with the three vector problem

(L_d, S_{d+m}, s_n) both of which have been applied. The Landé interval constant is chosen whenever possible from the ion (d^k configuration) and the exchange integrals are determined from experimental data. Consistent values are obtained for these integrals as they turn out to vary but slightly among adjacent ions. Configurations with an s electron added to an ion with Russell-Saunders coupling (other than Houston's singlet-triplet case) have also been examined as a three vector problem. Some examples treated are: Ti II, $3d^2(^3F)5s$; Fe I, $3d^7(^4F)5s$; Co I, $3d^8(^3F)4s$, $3d^8(^3F)5s$; Co II, $3d^7(^4F)5s$; Ni II, $3d^8(^3F)5s$.

6. Energy Levels for a Potential Function Having Symmetrical Double Minima and Applications to the NH_3 and ND_3 Molecules. MILLARD F. MANNING, *Massachusetts Institute of Technology*.—Exact solutions for the Schrödinger equation can be found when the potential energy is given by the expression

$$V=\frac{1}{k\rho^2}\left[-C\,\mathrm{sech}^2\frac{r}{2\rho}+D\,\mathrm{sech}^4\frac{r}{2\rho}+\mu^2\,\mathrm{sech}^6\frac{r}{2\rho}\right],$$

where $k=8\pi^2m/h^2$, r is the coordinate, and C, D, ρ and μ are arbitrary constants. For certain ranges of the constants the eight lowest energy levels have been found by numerical solution of continued fractions. Values of the constants have been found which give reasonable agreement with the experimental data for NH_3 and ND_3.

7. The Energies of Some Hydrocarbon Molecules. ROBERT SERBER, *University of Wisconsin*.—The energies of a number of hydrocarbon molecules have been calculated by the Heitler-London-Pauling-Slater method with two objects in view, first, to see if simple electron pair bonding leads to the correct heats of formation, and second, to determine what significance can be attached to the empirical additivity rule for bond energies. In calculating the energies it is not necessary to know the individual carbon-carbon exchange integrals, other than C_{rrrr}, since fortunately these integrals appear in the same linear combination in all the molecules considered except acetylene. For acetylene we have used values of the exchange integrals kindly supplied the writer by Dr. W. G. Penney. Simple electron bonding has been used for $\sigma-\sigma$ bonds and for single $\pi-\pi$ bonds. However, for the multiple $\pi-\pi$ bonds in acetylene and benzene it has been found necessary to employ more accurate methods. The $C-C$ gross bonding energy has been fixed from the observed energy of ethane, and C_{rrrr}, which then determines the energy of the $C=C$ bond, has been chosen to fit the observed energy difference between ethane and ethylene. In this way we find the suspiciously large value $C_{rrrr}=3.47$v. The calculated energies are given in the following table.

		Obs.	*Calc.*
Ethane	C_2H_6	29.6v	29.6v
Propane	C_3H_8	41.8	41.5
Butane	C_4H_{10}	54.1	53.5
Ethylene	C_2H_4	23.8	23.8
Propylene	C_3H_6	36.1	35.3
Acetylene	C_2H_2	17.2	17.1
Benzene	C_6H_6	58.2	55.7

The validity of an exact additivity rule for bond energies seems to be purely fortuitous.

8. Zeeman Effect of the Spectra of Arsenic. W. M. BARROWS AND J. B. GREEN, *Ohio State University*.—The spectra of arsenic have been studied in magnetic fields of about 36,000 gauss. The classifications of As I, As II and As III by Meggers, Rao and Lang, respectively, have been found to be in general agreement with the observed Zeeman effects. g-values have been calculated for As I and As II, with the results of Slater, of Houston, of Johnson and of Inglis for the electrostatic coupling energy and although, in some cases, the configurations are not far from LS coupling, the g-values thus found are in very satisfactory agreement with the observations.

9. The Paschen-Back Effect. II. jj-coupling. J. B. GREEN AND R. A. LORING, *Ohio State University*.—The $6s\,6d$ configuration of Hg I is very close to jj-coupling, the $^3D_1$ and $^1D_2$ terms being separated by only 3 cm^{-1}, and affords an excellent test of Houston's results for this type of interaction. Four pairs of lines, λλ5790, 3663, 3131, 2967, were studied, with fields of about 36,000 gauss, and down to about 10,000 gauss. Houston's calculations have been extended to include Paschen-Back effect in addition to the simple Zeeman effect, both for position and intensity of the components. The experiment is in excellent agreement with the calculated values and furnishes some very interesting patterns which would be difficult to interpret without the aid of the theory. For example, λ5789 $^1P_1-{}^3D_1$ appears as only one side of a Zeeman pattern with an ordinarily "forbidden" component comparable in intensity to the "permitted" lines.

10. $^3S_1$ and $^3D_{3,2,1}$ Terms in Mercury. I. WALERSTEIN, *Purdue University*.—Wave-length measurements of the higher terms in the triplet sharp and diffuse series of the mercury arc spectrum were made in order to determine whether these terms follow exactly a Ritz equation. This question was raised by Shenstone and Russel (Phys. Rev. **39**, 416 (1932)) in their study of perturbed series. A beam of excited mercury vapor which was allowed to diffuse from a mercury arc into a high vacuum chamber was photographed and the $2^3P_2-m^3S_1$ series was measured to $m=20$. Copper introduced into the mercury gave a sufficient number of lines in the beam of mercury vapor to make accurate measurements of the wave-lengths possible. (Iron used in a similar manner gave a fully developed spectrum in the mercury arc, but was completely absent in the vapor beam.) The terms obtained from the $2^3P_{2,1,0}-m^3S_1$ lines for the $^3S_1$ levels were found to obey correctly a Ritz formula. Similarly the $^3D_3$ terms were developed to $m=26$ and found to follow a similar law. The $^3D_2$ terms were also measured to $m=23$, and the $^3D_1$ terms to $m=19$.

11. Action Cross Section in Collisions of the Second Kind. O. S. DUFFENDACK AND J. H. MANLEY, *University of Michigan*.—The relative intensities of a group of lines in the spectrum of Mg II as excited by a low-voltage arc in a mixture of magnesium vapor and neon have been measured at various pressures of neon. Marked effect due to collisions of the second kind between magnesium atoms

and neon ions or metastable atoms is found. The ratio of intensities at 2.0 and at 0.017 mm neon was taken as a measure of the enhancement or the relative collision section for the excitation of a level by these resonant effects. In cases of close resonance the results indicate a cross section of some 600 (six hundred) times that for electronic excitation but a finite section for exact resonance. Dependence of cross section on series as well as energy-discrepancy is shown by an excitation preference of terms in the order *f–s–d*, at a given energy discrepancy.

12. Ionization Potentials in the Iso-electronic Sequence A I to Mn VIII. P. GERALD KRUGER AND S. G. WEISSBERG, *University of Illinois.*—The only two lines which connect the $3p^5 4_s$ terms and the $3p^6\ {}^1S_0$ term of ions like Ti V, V VI, Cr VII and Mn VIII are $3p^5 4_s\ {}^1P_1$, $^3P_1$ to $3p^6\ {}^1S_0$. Lines corresponding to these radiations have been observed with a twenty-one foot grazing incidence vacuum spectrograph for all of the above ions. This permits a calculation of the term value of the $^1S_0$ terms and the ionization potentials. Table I gives these values with the first and second differences between the ionization potentials.

TABLE I.

Ion	$3p^6\ {}^1S_0$ in cm^{-1}	Ionization potential in volts	First difference	Second difference
A I	127,104	15.679		
			16.0	
K II	256,637	31.66		3.3
			19.3	
Ca III	413,127	50.96		4.0
			23.3	
Sc IV	(602,000)	(74.3)		4.0
			27.3	
Ti V	824,000	101.6		3.8
			31.1	
V VI	1,076,000	132.7		3.8
			34.9	
Cr VII	1,359,000	167.6		3.8
			38.7	
Mn VIII	1,672,000	206.3		

FRIDAY MORNING AT 9:30 O'CLOCK

Hutchins Hall, Room 150

13. Fluorescence and Photodecomposition in Solutions of Chlorophyll *a*. V. M. ALBERS AND H. V. KNORR, *Kettering Foundation, Antioch College.*—The fluorescence spectrum of chlorophyll *a* in solution in anhydrous acetone, benzene and methanol has been photographed by a method previously described (H. V. Knorr and V. M. Albers, Phys. Rev. **43**, 379 (1933)). The solutions were exposed continuously to the radiation from four, 150 watt, Pyrex mercury arcs. The spectrograms were obtained by making a five minute exposure during each fifteen minute interval. Densitometer curves obtained from the spectrograms indicate that the fluorescence bands are not simple broad bands but are complex. The apparent shift previously observed in the positions of the bands can be attributed to a change in relative intensities of the individual bands and to the appearance of new fluorescence bands due to new compounds formed photochemically.

14. Fluorescence and Photodecomposition in Solutions of Chlorophyll *b*. H. V. KNORR AND V. M. ALBERS, *Kettering Foundation, Antioch College.*—The fluorescence spectrum of chlorophyll *b* in solution in anhydrous acetone, benzene and methanol has been photographed by a method previously described (H. V. Knorr and V. M. Albers, Phys. Rev. **43**, 379 (1933)). The solutions of chlorophyll *b* were treated in the same manner as those of chlorophyll *a* described in the preceding abstract. The densitometer curves made from these spectrograms show more pronounced maxima than those for chlorophyll *a* and as photodecomposition proceeds these individual maxima remain at very nearly the same wavelength while their relative intensities vary considerably. Results with chlorophyll *b* indicate more definitely, than those with chlorophyll *a*, that the apparent shift in the position of the fluorescence band is due to variation in relative intensities of the individual band components.

15. Optical Constants and the Conduction Electrons of Beryllium and Silicon. H. M. O'BRYAN, *Massachusetts Institute of Technology.*—The optical constants of beryllium as measured by the phase shift of reflected light show an abrupt increase in the strength of absorption ($n^3K\nu$) at 5000A (2.5 volts) which coincides with the minimum of reflection found by Coblentz and Stair. The increasing reflecting power and constant value of the strength of absorption toward the infrared indicates the presence of empty levels very little above those filled with conduction electrons, to which transitions are possible through collisions with the lattice. Both the optical constants and the soft x-ray emission give much greater transition probabilities for electrons more than 2.5 volts below the surface of the Fermi-Dirac distribution of conduction electrons. Silicon and germanium show a more gradual increase in the strength of absorption from 1.5μ where both are almost transparent. The strength of absorption computed from the measurements of Pfesdorf on silicon shows a decrease at 5 volts making the width of the absorption band less than four volts, while the minimum width expected from soft x-ray emission is about 7 volts. This band has a total strength of one half electron per atom and silicon has two M_{II} electrons per atom.

16. Infrared Absorption Bands of Heavy Water Vapor. W. W. SLEATOR AND E. F. BARKER, *University of Michigan.*—The infrared spectrum of water vapor in which both hydrogen atoms have been replaced by deuterium has been

examined under high dispersion. As in the case of ordinary water vapor, two fundamental bands are observed, corresponding to ν_3 and ν_2, the former but not the latter having a zero branch. The band associated with the symmetrical vibration ν_1 is probably weak, and has not been identified. The positions of the observed band centers are approximately

	ν_2	ν_3
heavy water:	1179 (8.48μ)	2784 (3.59μ)
ordinary water:	1596 (6.26μ)	3742 (2.67μ)

The wave number differences between the first line in the positive branch and the first line in the negative branch of ν_2 are 22.7 for the heavy molecule and 30.3 for the lighter one. Differences in relative intensities of the lines indicate the change in statistics when deutons replace protons in the molecule. An exact correspondence between lines in the bands ν_3 for the two varieties of water is difficult to establish, but the envelopes observed when the resolution is not too high are very similar in appearance. The maxima of the positive and negative branches are separated by about 115 cm^{-1} for the heavy molecule and 200 cm^{-1} for ordinary water.

17. Curved-Crystal X-Ray Spectrograph and Demountable Secondary-Radiation Tube for Analytical Work. RICHARD L. DOAN, *University of Chicago.*—A spectrograph has been built utilizing the focussing property of a curved crystal (mica or gypsum) first proposed by Guoy in 1916 and recently applied successfully by Cauchois. The crystal is bent to a radius of curvature of 50 cm and is clamped tangentially to a circle of 25 cm radius along which the line radiation is focussed after transmission through the crystal. The instrument can be evacuated for the longer wave-lengths. A dispersion of 10 X.U. per mm can easily be obtained and resolution is high since the lines are sharply focussed. As a generating source of both primary and secondary radiation for use in connection with the above spectrograph a demountable single-end tube of a general type developed by Dershem is employed. The fluorescing element is the surface of a slotted cap fitting over the filament and paralleling the target surface at a distance of a few millimeters. The arrangement is such that the primary and secondary radiation come out opposite sides of the tube through windows covered with beryllium foil. For compactness the filament lead is sealed close to the filament and brought out through a water path for cooling.

18. A Proposed High Resolving Power X-Ray Grating Spectrometer. ELMER DERSHEM, *University of Chicago.*—Grating measurements of x-ray spectra at present lack the desired precision principally due to the following causes. The beam is collimated for plane gratings by slits. This limits the number of useful rulings. Also the very high theoretical resolving power for inside orders cannot be utilized due to increased angular width of the diffracted beam caused by lack of parallelism of the incident rays. Concave gratings are imperfect at small glancing angles of incidence and also the diffracted rays are nearly parallel to the photographic plate. It appears possible to achieve a very greatly increased resolving power by using a section of a parabolic glass or speculum metal mirror. This section to be so chosen that x-rays diverging from a slit fall upon the mirror at a small glancing angle and are reflected in parallel rays to a plane grating. The diffracted beam is then brought to a focus by a second parabolic mirror. Calculations from data concerning the reflecting powers of various mirrors indicate that the theoretical resolving power should be 100 to 10000 times that attainable with a plane grating used with collimating slits. Construction of such an instrument is being planned.

19. A Simple Method for Demonstrating and Measuring Approximately the Index of Refraction of X-Rays. H. C. HOYT AND GEO. A. LINDSAY, *University of Michigan.*—A spectrum line may be formed by reflection at the surface of a crystal even if that surface is not parallel to the atomic planes concerned in the reflection. If the faces are good very close to the line of their intersection, then, with a slit that is not too narrow, the same line may be reflected simultaneously from the two faces of a stationary crystal, by turning it so that for the proper reflecting angle the rays must fall at the intersection. If the wave-length of the line is such that the reflected beam from the beveled face emerges from that face at nearly grazing incidence then that portion will be refracted much more than the portion of the line reflected from the other face, and the two parts of the line are plainly separated. A very simple calculation gives the index of refraction from the width included between the two portions of the line. In this way (δ/λ^3) for a cerussite crystal has been found to agree fairly well with the calculated value.

20. Factors Causing Deviations in X-Ray Ionization Measurements. ROY C. SPENCER, *University of Nebraska.*—The following pertains to new equipment recently installed. (1) *Fluctuations in voltage.* Reduced by using a synchronous motor generator. (2) *Slow changes in filament current of the x-ray tube.* Filament operated from storage batteries floated across the field supply of the generator. (3) *α-Particles*—Reduced by methods described by Bearden. (4) *Statistical fluctuations in the number of quanta received.* Statistical theory shows that for N quanta the standard deviation is $N^{\frac{1}{2}}$. If, as in the photoelectric effect, one quantum produces one electron, then $QP^2 = 1.59 \times 10^{-15}$ where Q is the charge in coulombs and P is its standard deviation in percent. For x-ray ionization in air (assuming Kulenkampff's value of 35 volts per ion pair between 0.56 and 2A) one quantum of 1A wave-length will produce 352 pairs of ions. The corresponding equation becomes $\lambda QP^2 = 5.6 \times 10^{-13}$ where λ is the wave-length in A. The sensitivity of the FP-54 circuit must, therefore, be reduced for use with x-rays. Weak currents may be best studied by allowing the system to charge up for a long time, the sensitivity being reduced by adding capacity and decreasing the galvanometer sensitivity.

21. X-Ray Investigation of Lattice Recovery of Metals After Cold-Working. J. E. WILSON AND L. THOMASSEN, *Department of Chemical Engineering, University of Michigan.*—Copper, nickel, iron and a number of alloys have

been studied to find the time-temperature relationship of x-ray line sharpening on annealing. The line broadness of nickel was investigated as a function of annealing time at a constant temperature. After an initial drop, the broadness is constant for a certain time, then decreases to its original value. For constant annealing time, individual metals vary widely both in temperature of initial line sharpening and in temperature range of the complete recovery process. For completion of the second stage of line sharpening, an expression $T=K_1/(\log t+K_2)$ is found, where T is annealing temperature in °abs., t is annealing time in seconds, and K_1 and K_2 are characteristic constants of the metal. Results have been correlated with hardness measurements and available data on electric and magnetic recovery from cold work. These stages of recovery and recrystallization have been interpreted on basis of reformation of undisturbed outer electron shells and differences in rates of diffusion of atoms.

22. Magnetic Susceptibilities of Powdered Crystals. R. B. JANES, *University of Wisconsin.* (*Introduced by C. E. Mendenhall.*)—The magnetic susceptibility of a number of powdered salts has been measured by the Gouy method over the temperature range 20 to −192°C. The work done falls into two divisions. The first is the measurement of the susceptibility of several palladium salts. All of these are diamagnetic, thus diverging from the theory which holds for the iron group. The second part of the work correlates the magnetic susceptibility and the color of salts of the iron group. From their constitution most of these salts should have the same sort of crystalline fields as assumed by Van Vleck for the hydrates of these metals, and which in the case of the hydrates leads to good agreement between theory and experiment. In the work done, when the color of the salt investigated is nearly the same as that of the hydrates the susceptibility is also nearly the same. This is not true if the color is different. Many salts were also investigated which had the color of the hydrates at the higher temperatures but different colors at lower temperatures. The susceptibility at the higher temperatures was in this case also like the hydrates but it was different at the lower temperatures.

23. The Crystal Structure of Lithium Sulphate Monohydrate. G. E. ZIEGLER, *University of Chicago.*—The crystal structure of $Li_2SO_4\cdot H_2O$ was investigated because the atomic numbers are favorable for determining the role of H_2O in the structure. The oxygen of the H_2O was found located at one corner of a tetrahedron of oxygen surrounding one of the lithium atoms. Since x-ray data can give no information regarding hydrogen, the hydrogen is located by a consideration of the structure surrounding the oxygen of the H_2O. The position selected as being most probable resulted in an angle of 108° for H−O−H. $Li_2SO_4\cdot H_2O$ is monoclinic with a unit cell $a=5.43$A, $b=4.84$A, $c=8.14$A, and contains 2 molecules. The space group assigned, C_2^3 contains only two fold general positions, x, y, z; $\bar{x}, y+\frac{1}{2}, \bar{z}$, which necessitated the determination of the following 23 parameters.

S	75°	0°	−76°	1.13A	0.00A	−1.72A
O_1	55	−50	−30	0.83	−0.67	−0.68
O_2	180	−10	−69	2.71	−0.13	−1.56
O_3	28	−28	−143	0.42	−0.37	−3.23
O_4	58	110	−71	0.87	1.47	−1.60
O_5	205	170	−139	3.09	2.28	−3.14
Li_1	−25	195	−139	−0.38	2.61	−3.14
Li_2	60	172	+1	0.90	2.31	+0.02

Sulphur and the two lithium atoms are each surrounded by tetrahedra of oxygen with the following average distances: S to O=1.49A, O to O in SO_4 tetrahedron =2.43, Li to O=1.99, O to O tetrahedra =3.20. The shortest O to O distance between oxygens of different SO_4 groups is 2.85. The LiO_4 tetrahedra share corners but not edges or faces.

FRIDAY MORNING AT 9:30 O'CLOCK

Hutchins Hall, Room 250

24. Spectroscopic Study of Restriking Phenomena in the a.c. Copper Arc. W. S. HUXFORD AND OLAV MASENG, *Northwestern University.*—The spectrum at various phases of an alternating-current copper arc in air has been investigated with particular reference to restriking phenomena. Currents from 17 to 27 amperes were supplied by a 15 kva 550 volt transformer. The arc circuit contained an air core coil with a maximum inductance of 0.06 of a henry. Light from the arc was passed through a narrow slit in a disc driven by a synchronous motor which limited the exposures to approximately one degree of cycle. No marked changes in relative line intensities were noted except near and during the "current zero" phase of the arc. The spectrograms show positive and negative bands of nitrogen appearing at the surface of the incoming cathode. These bands persist over a period of the cycle which coincides precisely with that of the "glow" state as revealed by current-potential plots. The period during which the glow discharge persisted at one of the electrodes could be varied, and with an arc 3 cm long periods up to 30° of cycle were obtained. The results indicate that the enveloping gas plays an important part in the restriking of a metal arc.

25. The Initiation of Discharges in Ion Free Gases. J. W. FLOWERS AND J. W. BEAMS, *University of Virginia.*—A study has been made of the breakdown of highly overvolted spark gaps (see Street and Beams, Phys. Rev. **38**, 416 (1931)). The gas surrounding the spark gap was carefully dried and filtered. Ions in the gap were removed by auxiliary electrical fields. The potential across the gap in each case was applied for the order of magnitude of 10^{-6} sec. With spherical brass electrodes fields of roughly 5×10^5 volts per cm were required to start the discharge in hydrogen, nitrogen, helium or air. With a wire (tungsten or

platinum) and a cylinder (steel) for electrodes the field at the wire necessary to produce breakdown was independent of pressure over the range from 35 cm to 76 cm of Hg. Also it only varied by a few percent with nitrogen, hydrogen or helium in the gap. The field necessary to produce breakdown with the wire electrode negative (about 5×10^5 volts per cm for platinum) was roughly 20 percent less than with the wire positive. Results similar to the above were obtained with point and plane electrodes. It is believed that in cases where the wire or point was negative the discharge was initiated by electrons arising from field emission from the cathode. The fall of potential, during breakdown, across these effectively ion free gaps was found to be much more rapid than for gaps in ordinary room air.

26. Observations on the Velocity of Sound in Arcs. C. G. SUITS, *Research Laboratory, General Electric Company, Schenectady, New York.*—A method has been developed for measuring the velocity of transmission of a single sound pressure front through arcs at atmospheric pressure. The sound is generated by a spark from a tungsten wire to an adjacent copper electrode. The sound receiver within the other copper electrode consists of a high voltage d.c. spark, the voltage of which changes during the passage of a sound wave. The time interval between the generation of the sound wave at one end of the arc and reception at the other end is observed on the cathode ray oscillograph. The arc is stabilized in a glass tube by means of a corkscrew air stream so that straight, cylindrical discharges, varying between 2 and 12 cm in length, can be used. By plotting arc length and time interval, the velocity V is obtained from the slope, free from end corrections. A preliminary value for a 6.3 ampere copper arc in air at atmospheric pressure is $V=1.3\times10^5$ cm/sec. From this the arc temperature is calculated to be 4300°A. Corrections due to dissociation decrease this value by a small amount.

27. Energy Distribution in the Spectrum of Some Incandescent Lamps. W. E. FORSYTHE AND B. T. BARNES, *Incandescent Lamp Department, General Electric Company, Cleveland, Ohio.*—The intensity for standard temperature and efficiency of the radiation in the spectrum of a number of tungsten lamps has been measured for a range of wavelengths from about 3000A to 27,000A. The values obtained by direct measurements were checked in the visible spectrum by comparison with the relative values obtained from color match data of the same tungsten lamps. Values thus obtained agreed to within a percent or two throughout the visible spectrum.

28. Thermionic Electron Emission from Tungsten. W. B. NOTTINGHAM, *Massachusetts Institute of Technology.*—The electron current from an equipotential surface at 1857°K has been observed as a function of the potential v from -3.5 to 750 volts. Over the range -3.5 to -1.5 the Maxwellian curve is an exact representation of the data while between -1.5 and -0.6 volt the observed current falls below the theoretical curve. The current at -0.6 volt (zero field) is about 50 percent below that expected. The extrapolated Schottky mirror image curve obtained from the high field data falls very close to the extrapolated Maxwellian curve. Energy distribution curves taken at nine temperatures between 1218°K and 1857°K, when plotted as a function of v/T, are all exactly alike. This indicates that the effective integrated transmission coefficient at zero field is independent of the temperature and is therefore probably controlled by mechanical imperfections of the wire such as die marks, crystal irregularities, etc. If the contact potential between the filament and the collector followed the equation $V=V_0+\alpha 8.62\times10^{-5}\ T$ (where αk = temperature coefficient in ergs per degree and V_0 = contact potential at 0°K), then by plotting the observed relative positions of zero applied potential as a function of $1/T$ for the superimposed set of observed curves, the values of V_0 and α could be obtained from the slope and the intercept, respectively. This assumes that we know the contact potential at a single temperature. Observed results seem to follow two lines instead of one. This interpretation gives $\alpha=-1.1$ for 1857° to 1625° and $\alpha=-1.6$ for 1508° to 1218°K. If the best single line through all points is chosen $\alpha=0.68$.

29. The Energy Distribution of Photoelectrons from Sodium and the Photoelectric Determination of h/e. L. A. DUBRIDGE AND A. G. HILL, *Washington University, St. Louis, Mo.*—The recently developed theory of the energy distribution of photoelectrons (DuBridge, Phys. Rev. **43**, 727 (1933)) shows that the Einstein equation connecting the *maximum* energy of emission V_m with the frequency should hold accurately only at 0°K. At higher temperatures there is a temperature tail which may be extrapolated to yield an *apparent* maximum energy V_a. It is a matter of good fortune that it turns out that V_a is also a linear function of the frequency with the slope h/e, approximately. There is however no exact theoretical basis for this relation. The new theory gives a method of determining a V_m which should accurately fit Einstein's equation. The present experiments extend Roehr's previous confirmation of the theory to a sodium surface over a wave-length range from 2400 to 5460A. Plotting V_m against ν gives a value of h/e about 2 percent greater than that obtained by plotting V_a against ν. This raises the question of a possible systematic error in previous photoelectric determinations of h/e. More precise experiments are necessary and are being planned to investigate this question.

30. The Photoelectric Emission from Thoriated Tungsten. R. E. SMITH AND L. A. DUBRIDGE, *Washington University, St. Louis, Mo.*—A complete set of photocurrent *vs.* frequency curves was obtained for a 12 mil thoriated tungsten filament in various stages of activation. In this preliminary work, photoelectric measurements were restricted to single temperature (900°K) and to a single accelerating field (100 v on the collector). Gas-free conditions were maintained throughout. It was found: (1) At any stage of activation the photocurrents vary with frequency according to Fowler's equation, out to frequencies as much as 1.3 volts from the threshold. Fowler's theory thus applies to composite surfaces as well as clean. (2) Beyond 1.3 volts from the threshold the points fall

below the Fowler curve, as expected. (3) At each stage of activation the photoelectric work function at 900°K (by Fowler's method) agrees with the thermionic work function, for an average temperature of 1400°K, within the limits of error. The values range from 2.6 to 4.52 v in agreement with previous thermionic work. (4) At higher activation there is a tendency for ϕ_p to be less than ϕ_t by an amount just about equal to the possible error (0.05 volt). This may be a real temperature effect. (5) The value of the constant B in Fowler's equation is the same for all surface conditions.

31. Temperature Variation of the Second Virial Coefficient for Helium. NEILL G. WHITELAW, *University of Wisconsin.*—The temperature dependence of the second virial coefficient for helium may be obtained quite accurately from the recent measurements of Roebuck and Osterberg (Phys. Rev. **43**, 60 (1933); **45**, 332 (1934)) on the Joule-Thomson effect for that gas. If the equation of state be written $PV/RT=A+B/V+\cdots$, one easily derives the relation $(d/dT)(B/T)=\mu C_p/T^2$, where μ is the Joule-Thomson coefficient. The quantity $B/T-B/T_0=K$, was found by graphical integration over the range of temperature, −190 to 300°C, for which Roebuck and Osterberg measured μ. Excellent agreement with the recent pressure volume determinations of B by Keesom and Van Santen (Comm. No. 227b, Leyden) is obtained for the limited range 0–100°C, which their measurements cover. If the constant of integration is determined so as to agree with Keesom and Van Santen at 0°C, we obtain $B_{100}=0.4813\times10^{-3}$, while they find $B_{100}=0.4814\times10^{-3}$.

32. The Joule-Thomson Effect in Nitrogen Argon and in Mixtures of Nitrogen and Helium. J. R. ROEBUCK AND H. OSTERBERG, *University of Wisconsin.*—Continuing the work on the Joule-Thomson effect in gases already reported (Phys. Rev. **45**, 332 (1934)), the isenthalpic curves for nitrogen and for argon have been measured over the range 1 to 200 atm., and −160° to +300°C. The general character of the families of curves is very similar to that for air. The upper and lower branches of the inversion curve of the Joule-Thomson coefficient fall within these temperature limits for nitrogen but for argon the upper branch is entirely above 300°C. The data for both gases are now the process of smoothing and will be used to calculate some of the properties, as well as to calculate the Kelvin temperature of the ice point. Measurements have also been made on four mixtures of helium and nitrogen over a more limited range of temperature. The shift in character of the family of isenthalpic curves with change in composition from nitrogen toward helium is very similar to the shift in character of one pure gas with rise in temperature. Experimental work will proceed next with helium-argon mixtures, and with pure carbon dioxide.

33. Precision Determinations of the Variation of the Dielectric Constant of Benzene with Temperature. JOHN A. MORROW, *University of Florida.* (*Introduced by A. A. Bless.*)—Precise determinations of the dielectric constant-temperature curve for benzene seemed highly desirable in view of the incomplete and inconsistent nature of the data in literature. A heterodyne beat circuit of unusual stability using a pentode tube and a check circuit was employed. Differences rather than total capacities were measured with a maximum error which corresponded to ±0.00003 in the value of the dielectric constant or 1.6 percent of its temperature coefficient. Definite discontinuities were found in the capacity-temperature curve for benzene hydrated between certain limits, but an exact linear relation exists for highly dehydrated benzene. The temperature coefficient was determined to be −0.00193, as compared with Goss and Graffunder's value of −0.00195. The temperature coefficient of the dielectric constant of *n*-heptane, which does not seem to be in the literature, was determined to be −0.00143.

34. The Variation of the Dielectric Constant of a Viscous Dielectric with Temperature and with Frequency. A. A. BLESS, *University of Florida.*—The dielectric constant of tung oil was measured as a function of temperature for a number of frequencies. The constant increases at first with decreasing temperature and then decreases after passing through a maximum. The Debye theory accounts qualitatively very well for this behavior, however, the quantitative agreement is not very good. The application of the theory of polar molecules to the region of maximum value of the dielectric constant gives for the product of the frequency and the relaxation time $(k+a/T+b/T^2)^{\frac{1}{2}}$ where k, a and b, are measurable constants of the substance and T is the temperature. Comparison with experiment shows that this relation is only approximately true. Experiments also indicate the existence of rotation of these large molecules in the solid state, and show therefore that the relaxation time of the molecules is not proportional to the viscosity of the substance, except perhaps for very small values of the latter.

35. Effect of X-Rays on the Dielectric Constant of Various Liquids. J. FRED PAYNE, JR., *University of Florida.* (*Introduced by A. A. Bless.*)—A beam of x-rays from a Coolidge water-cooled tube, run at 15 milliamperes and 60,000 volts, was directed on a test cell connected to a heterodyne circuit for observing changes in capacity. The apparatus was completely shielded from thermal and electrostatic disturbances, and was piezo-electrically controlled. Changes in dielectric constants as slight as 0.001 of 1 percent could be measured, and variations of much smaller magnitudes could be detected by ear from changes in the beat note between a 1000 cycle electrically-driven tuning fork and the audio note generated by the oscillators and amplified by a resistance coupled amplifier. The following liquids were tested: benzene, nitro-benzene, ether, methyl alcohol, tung oil, and transformer oil. None of these liquids showed any perceptible changes in the dielectric constant due to x-rays. The absence of the effect indicates that the rate of recombination is very high and that the life of the ions formed by x-rays is less than 0.01 sec. at room temperature. Experiments are now in progress to determine the life of ions at lower temperatures.

Friday Afternoon at 2:00 O'clock

Hutchins Hall, Room 100

PUBLIC ADDRESS

36. The General Nuclear Problem. George Gamow, *Polytechnical Institute, Leningrad, Russia.*

Saturday Morning at 10:00 O'clock

Hutchins Hall, Room 100

SYMPOSIUM

ON

NUCLEAR MOMENT

37. Theory of the Effect of a Nuclear Moment on the State of the Atom. G. Breit, *New York University.* 25 minutes

38. Measurement of Nuclear Spin and Statistics by Means of Band Spectra. Robert S. Mulliken, *University of Chicago.* 15 minutes

39. Survey of Experimental Hyperfine Structure Material. Values of Nuclear Magnetic Moments and a Discussion of Their Origin. Robert F. Bacher, *University of Michigan.* 25 minutes

40. Measurement of Nuclear Spin and Moments by Method of Molecular Beams. I. I. Rabi, *Columbia University.* 20 minutes

41. Measurement of Nuclear Moments and Spin Through the Polarization of Resonance Radiation. Alexander Ellett, *State University of Iowa.* 20 minutes

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.

42. Application of the Forsythe-Watson Temperature Scale for Tungsten. W. B. NOTTINGHAM, *Massachusetts Institute of Technology.*—Forsythe and Watson (J. Opt. Soc. Am. **24**, 114 (1934)) have published new values of resistivity R and total radiation W characteristic of pure tungsten wire as a function of the temperature. The "derived functions" of Langmuir-Jones, namely $VA^{1/3}/l = X$ and $A/d^{3/2} = Y$, are more useful for the determination of the temperature in well evacuated tubes than the specific functions R and W. (R=resistivity in micro-ohm cm; W=total radiation watts per cm^2; V=potential drop over uniform filament in volts; A=current in amp.; l=length in cm; d=diameter in cm.) Tables and curves showing dependence of X_0 and Y_0 on temperature have been computed directly from R and W which apply for surroundings at 0°K from the relations $X_0=(4\Pi)^{1/3}W^{2/3}R^{1/3}$ and $Y_0=\Pi W^{1/2}/2R^{1/2}$. In order to determine the temperature from observed values of V, A, l and d the following correction formulae are useful:

$$X_0=X\left(1+\frac{2}{3}\frac{W_1}{W_2}+\frac{2}{3}\frac{d}{c}-\frac{2}{3}\frac{\Delta d}{d}\right),$$

$$Y_0=Y\left(1+\frac{1}{2}\frac{W_1}{W_2}+\frac{1}{2}\frac{d}{c}+\frac{\Delta d}{d}\right).$$

W_1/W_2=ratio of the W's for room temperature and filament temperature, respectively. In case the filament is surrounded by a collector of diameter c which has approximately the same total emissivity as tungsten over the temperature range 300°K to 600°K, the third term should be used. (Omit if the collector forms part of the outside wall.) On account of die grooves found on most filaments the true outside diameter as determined by an interferometer gauge is larger than that obtained from the weight or the resistance. The difference in these diameters is Δd. Although the Forsythe-Watson values of R and W differ appreciably from those of Langmuir and Jones, temperatures calculated from the two scales agree remarkably well over the range 900°K to 2200°K and show about the same degree of self-consistency which is not quite perfect.

(To be called for in Room 250.)